A global carbon-isotope event in the Middle Turonian (Cretaceous) sequences in Japan and Russian Far East

著者	Hasegawa Takashi
journal or publication title	Proceedings of the Japan Academy Series B: Physical and Biological Sciences
volume	79
number	6
page range	141-144
year	2003-06-01
URL	http://hdl.handle.net/2297/10558

A global carbon-isotope event in the Middle Turonian (Cretaceous) sequences in Japan and Russian Far East

By Takashi HASEGAWA

Department of Earth Sciences, Faculty of Science, Kanazawa University
Kakuma-machi, Kanazawa, Ishikawa 920-1192
(Communicated by Tatsuro MATSUMOTO, M. J. A., June 10, 2003)

Abstract: A time-diagnostic positive excursion (~1‰) of carbon isotope ratio ($\delta^{13}C$) recorded in organic matter from the Middle Turonian (Late Cretaceous) clastic sequences in Japan and Russian Far East provides inter-regionally recognizable chemostratigraphic keybed at 90.7 Ma. Compilation of recent studies on carbon-isotope stratigraphy for this region revealed that the $\delta^{13}C$ event is located in the middle of gradual ~1.5‰ negative shift above the prominent Cenomanian/Turonian boundary $\delta^{13}C$ "spike". Limited occurrences of cosmopolitan age-indicative ammonoid species, *Collignoniceras woollgari* revealed that the range of this species encompasses the $\delta^{13}C$ event horizon confirming its utility as an international chemostratigraphic keybed, whereas the common occurrence of *Inoceramus hobetsensis* across the $\delta^{13}C$ event benefits identifying this important marker horizon.

Key words: *Inoceramus*; *Collignoniceras*; Cretaceous; carbon isotope; correlation; biostratigraphy; Hokkaido; Sakhalin.

Introduction. Biostratigraphy of inoceramid bivalves has provided a convenient time scale in Japan because of their abundant occurrence than ammonoids. In order to achieve indirect correlation between the Japanese inoceramid biostratigraphy and European chronostratigraphic units, occasional occurrences of age-indicative ammonoids have often been employed for the age assignment of Japanese inoceramid zones.[e.g.1),2)]

On the other hand, correlation based on carbon-isotope stratigraphy have been developed to be prerequisite for detailed correlation both for carbonate[e.g.3),4)] and clastic sequences[e.g.5)-7)] in this decade. Recent studies on carbon-isotope stratigraphy in Japan and Russian Far East[6),8)-12)] demonstrated the synchronous fluctuation of carbon isotope ratio ($\delta^{13}C$) between Asian fore-arc basin sediments and European carbonates through the Upper Cretaceous. In another word, carbon-isotope stratigraphy enables us to correlate Asian clastic sediment with European stratotype using general configuration of their $\delta^{13}C$ profiles. However, any $\delta^{13}C$ event except for that across the Cenomanian/Turonian (C/T) boundary[6)] has not been discussed as a precise chemical datum plane for the fore-arc basin sediments. Recently, Voigt and Wiese[4)] discussed very detailed correlation of European carbonate sequences based on $\delta^{13}C$ stratigraphy. They defined five horizons of carbon-isotope events as stratigraphic datum planes for the Middle and Upper Turonian. Voigt[13)] compiled European $\delta^{13}C$ profiles for Cenomanian and Turonian, and showed detailed relationships between carbon isotope stratigraphy, macrofossil zonation and radiometric age. These studies for European sequences imply that detailed $\delta^{13}C$ stratigraphy can provide an inter-regional correlation with higher resolution and accuracy unattainable with conventional biostratigraphy.

The present study compiles recent studies on carbon isotope stratigraphy established with macrofossil biostratigraphy in Japan and Russian Far East, and discusses a conspicuous peak in the Middle Turonian concerning its intra- and inter-regional synchroneity. Utility of this $\delta^{13}C$ event as an international chemostratigraphic keybed is discussed based on long-term configuration of $\delta^{13}C$ profiles and limited occurrences of a cosmopolitan age indicative fossil species.

Stratigraphic relationship between $\delta^{13}C$ profiles and biostratigraphy. Recently, Hasegawa and his colleagues revealed stratigraphic fluctuation of $\delta^{13}C$ value of terrestrial organic matter ($\delta^{13}C_{TOM}$) coupled

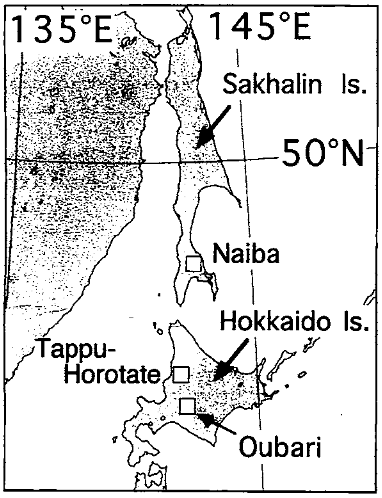

Fig. 1. Map showing locality of areas mentioned in this paper.

with stratigraphic distribution of an inoceramid species in the Oyubari area [Shuparo area by some authors] (Hokkaido, Japan),[8)-10),12)] Tappu-Horotate and adjacent areas (Hokkaido, Japan)[6),8),12)] and Naiba area (Russian Far East)[11)](Fig. 1).

Stratigraphic profiles of $\delta^{13}C_{TOM}$ value through the Turonian from these three sections show diagnostic configuration that can be comparable each other (Fig. 2b-d). Hasegawa and his colleagues[10),11)] concluded that major stratigraphic fluctuations of $\delta^{13}C_{TOM}$ reflect carbon-isotopic composition of atmospheric CO_2 although some minor local effect could disturb or bias the original signal.[14)]

Inoceramus hobetsensis Nagao and Matsumoto, an inoceramid bivalve species, is an important index of the Middle Turonian in Japan, Sakhalin and elsewhere[2)] because of its common occurrence.

Fig. 2b-d shows the stratigraphic relationship between the $\delta^{13}C_{TOM}$ profiles and the recognized range of *I. hobetsensis* (a shaded zone in Fig. 2). A positive $\delta^{13}C_{TOM}$ peak represented by nearly 1‰ excursion occurs within the range of *I. hobetsensis*. The peak (darkly shaded in Fig. 2) is located in the middle of the long-term negative shift (see a curve with arrowhead beside each $\delta^{13}C$ profile in Fig. 2) below the minimum value horizon in each stratigraphic profile of $\delta^{13}C$ value. These records observed in widely separated areas (more than 500 km) demonstrate that the peaks in these sequences are equivalent and stratigraphically correlative each other. It is very unlike that local noise or bias, or any secondary factors produced such region-wide characters after sedimentation (see discussion in separated papers[11),14)] for details concerning diagenesis of terrestrial organic matter). This chemostratigraphic event represented by positive 1‰ peak of $\delta^{13}C_{TOM}$ value within the stratigraphic range of *I. hobetsensis* is designated in this paper as "IH spike" that is as an abbreviation of "*I. hobetsensis* spike". The carbon-isotopic "bottom" event represented by most negative $\delta^{13}C_{TOM}$ value above the IH spike and just below the major positive migration observed in Fig. 2b, c and d is also a correlative horizon as well as the peak horizon of IH spike. The "bottom" event is observed above the last occurrence of *I. hobetsensis* in each of three sections and designated as PIH event [= post-*I. hobetsensis* event].

Chronostratigraphic importance of IH spike and PIH event. Most plausible factor that can produce region-wide extent of a $\delta^{13}C_{TOM}$ event is a fluctuation of carbon-isotopic composition of atmospheric CO_2. The carbon-isotopic composition of terrestrial organic matter (i.e. higher plants) should have shifted parallel with that of atmospheric CO_2, if the carbon-isotopic fractionation by the plants was consistent through time. Hasegawa *et al.*[11)] discussed atmospheric CO_2 as a major controlling factor for both short- and long-term fluctuations of $\delta^{13}C_{TOM}$ value in the Naiba section. However, they pointed out some potential factors that can superimpose additional signals on the initial atmospheric signals.[11),14)] Such factors other than $\delta^{13}C$ fluctuation of atmospheric CO_2 cannot affect on $\delta^{13}C$ values of carbonate carbon but on those of terrestrial organic carbon.[14)]

Carbonate is inorganically precipitated from CO_3^{2-} in sea surface water and reflects the $\delta^{13}C$ fluctuation of dissolved CO_2 in ambient water that should be equilibrated with atmospheric CO_2. If the carbon-isotopic IH spike and associated PIH event are derived from a maximum and a minimum of relative abundance of ^{13}C in atmospheric CO_2 respectively, correlative $\delta^{13}C$ events should be observed in carbonate carbon-isotope profiles from any regions of the world. In this case, IH spike and PIH event can act as global chemostratigraphic keybeds, just as the Cenomanian/Turonian boundary positive $\delta^{13}C$ excursion[e.g.3),10)] plays.

Correlative counterpart of IH spike in European carbonate sequences. Fig. 2a shows a composite $\delta^{13}C$ profile for carbonate carbon through Turonian[4),13)] exhibiting comparable feature with that of $\delta^{13}C_{TOM}$ profiles from Asian fore arc basin sediments (Fig. 2b-d). Gradual ~1.5‰ negative shift (indicated with an arrow in each profile in Fig. 2) from the break of "step-like" stable segment above the prominent C/T boundary peak is well observed. A positive ~1‰ excursion in the middle of the

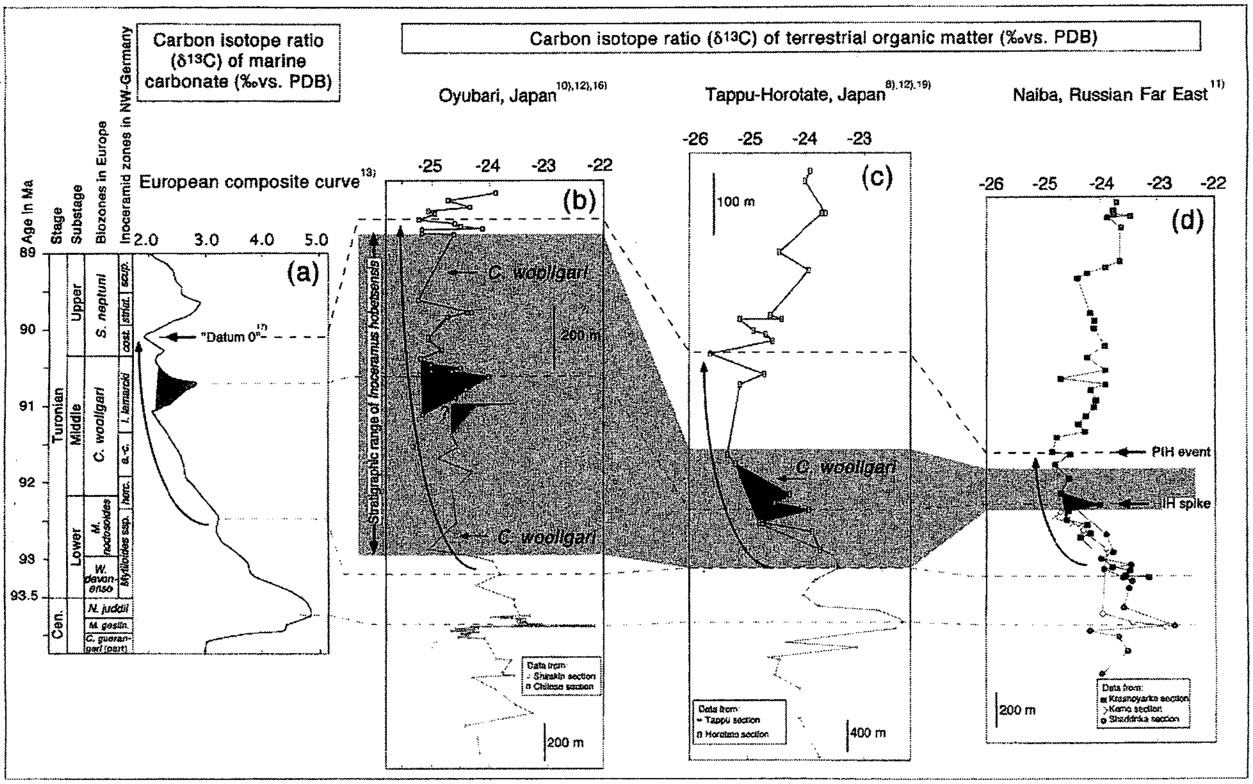

Fig. 2. Comparison of carbon isotope profiles for carbonate[13] and terrestrial organic matter from fore-arc basin sediments in Asia.[8),10)-12),16),19] Correlative $\delta^{13}C$ events are connected with broken lines. Shaded peaks indicate IH spike or the correlative carbon-isotopic event in Europe. See text for details.

gradual negative shift in the $\delta^{13}C_{TOM}$ profiles from Asia also characterize the $\delta^{13}C$ profiles for the European carbonate carbon. A candidate of the European counterpart of the IH spike is assigned to be in the *Collignoniceras woollgari* Zone (an ammonoid biozone), the Middle Turonian at 90.7 Ma based on recently compiled time scale.[13]

C. woollgari Zone is nearly identical to the total range of *C. woollgari* (Mantell) although the uppermost part of the range is projected into the lowermost part of *Subprionocyclus neptuni* Zone.[15] Limited occurrences of *C. woollgari* near the bottom and top of the range of *I. hobetsensis* in the Oyubari sequence,[12),16] and in the upper part of the range in the Tappu-Horotate sequences[12] show that the range of *I. hobetsensis* is correlative to that of *C. woollgari*. Hence biostratigraphic framework strongly supports the peak correlation between IH spike in the $\delta^{13}C_{TOM}$ profiles and similar positive ~1‰ excursion in *C. woollgari* Zone in European carbonate sequences. Recent stratigraphic study[17] in Germany applies the positive $\delta^{13}C$ event for intra- and inter-basial correlation demonstrating the stratigraphic importance of the event. IH spike and correlative event can offer a world-wide chemostratigraphic keybed.

A "minimum" event in European $\delta^{13}C$ profile ("Datum 0"[17]), that is comparable with PIH event, has also reported above the positive spike[17] and has been applied for correlation between European boreal and western Tethys regions. No biostratigraphic evidence supports the inter-regional correlation between European "Datum 0" event and Asian PIH event so far. Nevertheless, the overall $\delta^{13}C$ pattern observed in both regions agrees their identity. Further documentation on stratigraphic relationship between PIH event and the first occurrence of *S. neptuni* (Geinitz) in Asia will confirm this inter-regional correlation.

Conclusion. Stratigraphic fluctuation of $\delta^{13}C_{TOM}$ from fore arc basin sequences in Asia show conspicuous positive ~1‰ excursion within the total range of *Inoceramus hobetsensis*. This excursion, the *Inoceramus hobetsensis* (IH) spike, can be correlated with similar ~1‰ excursion in the $\delta^{13}C$ profiles of carbonate sequences in

Europe at 90.7 Ma, Middle Turonian within the range of *Collignoniceras woollgari*.[4),13)] Long-term trend of carbon-isotope stratigraphy and biostratigraphy well support this correlation. The carbon-isotopic IH spike provides a precise chemostratigraphic keybed for inter-regional correlation based on the short-term shift of $\delta^{13}C$ in oceanic/atmospheric CO_2 reservoir. Common occurrence of *I. hobetsensis* in Japan and Russian Far East well helps to identify this international chronostratigraphic marker.

Acknowledgments. The author expresses his deep appreciation to Prof. Emeritus T. Matsumoto, M. J. A., of Kyushu University for offering him an opportunity for this publication and helpful comments, and Dr. S. Toshimitsu for his critical reading of this manuscript. Grant-in-aid for Scientific Research (C), KAKENHI nos. 13640469 and 14604014 (given to T. Hasegawa), and Scientific Research (A), KAKENHI no. 13354006 (given to H. Nishi of Kyushu University) by J. S. P. S. financially supported this study.

References

1) Matsumoto, T. (1942) Mem. Fac. Sci. Kyushu Imp. Univ. Ser. D **1**, 129-280.
2) Toshimitsu, S., Matsumoto, T., Noda, M., Nishida, T., and Maiya, S. (1995) J. Geol. Soc. Japan **101**, 19-29 (in Japanese with English abstr.).
3) Jenkyns, H. C., Gale, A. S., and Corfield, R. M. (1994) Geol. Mag. **131**, 1-34.
4) Voigt, S., and Wiese, F. (2000) J. Geol. Soc. London **157**, 737-743.
5) Gröcke, D. R., Hesselbo, S. P., and Jenkyns, H. C. (1999) Geology **27**, 155-158.
6) Hasegawa, T., and Hatsugai, T. (2000) Paleontol. Res. **4**, 95-106.
7) Ando, A., Kakegawa, T., Takashima, R., and Saito, T. (2002) Geology **30**, 227-230.
8) Hasegawa, T., and Saito, T. (1993) Island Arc **2**, 181-191.
9) Hasegawa, T. (1995) J. Geol. Soc. Japan **101**, 2-12.
10) Hasegawa, T. (1997) Palaeogeogr. Palaeoclimatol. Palaeoecol. **130**, 251-273.
11) Hasegawa, T., Pratt, L. M., Maeda, H., Shigeta, Y., Okamoto, T., Kase, T., and Uemura, K. (2003) Palaeogeogr. Palaeoclimatol. Palaeoecol. **189**, 97-115.
12) Tsuchiya, K., Hasegawa, T., and Pratt, L. M. (2003) J. Geol. Soc. Japan **109**, 30-40 (in Japanese with English abstr.).
13) Voigt, S. (2000) Palaeogeogr. Palaeoclimatol. Palaeoecol. **160**, 91-104.
14) Hasegawa, T. (2003) J. Asian Earth Sci. **21**, 847-857.
15) Robaszynski, F. (1983) Zitteliana **10**, 585-594.
16) Matsumoto, T. (1971) Mem. Fac. Sci. Kyushu Univ. Ser. D Geol. **21**, 129-162.
17) Wiese, F., and Kaplan, U. (2001) Cret. Res. **22**, 549-563.
18) Stoll, H. M., and Schrag, D. P. (2000) GSA Bull. **112**, 308-319.
19) Hasegawa, T. (1994) D. Sc. Diss., Inst. Geol. Paleontol., Tohoku Univ., Sendai.